POTENTIAL OF CATIONIC SURFACTANT MODIFIED SILICA GEL IN

REMOVAL OF ORGANOPHOSPHATE PESTICIDE - MONOCROTOPHOS

FROM AQUEOUS SOLUTION

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ABSTRACT

The organophosphate insecticides are highly toxic by all routes of exposure. Repeated daily high level exposure may gradually lead to poisoning. Recycle & reuse of waste materials by using adsorption & adsolubilization would be the best option to remove pollutants from the surrounding environment at low initial cost & it is less energy consuming too. In the present study, cationic surfactant-(CS) Dodecyl Trim ethyl Ammonium Chloride-(DTAC) modified Silica Gel was used to remove Monocrotophos. Silica Gel was used to remove DTAC from aqueous solution. From the batch study pH6, contact time 30min, adsorbent dosage 30gm/L & high initial adsorb ate concentration 7500mg/L were found optimum experimental conditions for maximum 99.7%removal of DTAC by Silica Gel from aqueous solution. The Silica Gel, thus exhausted after removal of DTAC, is known as Cationic Surfactant Modified Silica Gel (CSMSG) & was further used to remove Monocrotophos from aqueous solution. From the batch study; pH4, contact time 20min & adsorbent dosage 8gm/L were found optimum experimental conditions for maximum 72.6% removal of Monocrotophos by CSMSG from aqueous solution. Temperature had no effect on %removal of Monocrotophos & almost 72.3% removal was observed at all the temperature ranges. Removal of Monocrotophos by CSMSG followed Pseudo Second Order Kinetic Model (Calculated q_e (2.7211mg/gm) & experimental q_e (2.72mg/gm) are in good agreement & R^2=1.0. From the adsorption isotherm study, R^2 obtained were in good agreement with Langmuir (R^2=0.83), Freundlich (R^2=0.90), Temkin (R^2=0.96) & BET (R^2=1). Maximum 68.4% removal of Organophosphate insecticide was observed for actual pesticide industry effluent sample.

KEYWORDS: Adsolubilization, Adsorption, CSMSG, Dodecyl Trimethyl Ammonium Chloride, Monocrotphos, Silica Gel

INTRODUCTION

Pesticides are substances meant for attracting, seducing, destroying or mitigating any pest [US Environmental, 2007]. The most common use of pesticides is as plant protection products (also known as crop protection products), which in general protect plants from damaging influences such as weeds, diseases or insects [Carolyn R., 2013]. Pesticides are often referred as according to the type of pest they control. Organophosphates affect the nervous system by disrupting the enzyme that regulates acetylcholine, a neurotransmitter. Most organophosphates are insecticides [Pesticide Wikipedia]. In health, agriculture, and government, the word "organophosphates" refers to a group of insecticides acting on the enzyme acetyl cholinesterase [US EPA]. Monocrotophos, an organ phosphorus compound, is a broad spectrum, systemic insecticide and acaricide (i.e. a substance poisonous to ticks or mites) used to control sucking, chewing and boring insects on horticultural and agricultural crops [Australian Government].

Entry of the Pesticides in to the Water Environment

There are four major routes through which pesticides reach the water: (i) it may drift outside of the intended area when it is sprayed, (ii) it may percolate or leach through the soil, (iii) it may be carried to the water as runoff, (iv) it may be spilled, for example accidentally or through neglect [States of Jersey, 2007]. They may also be carried to water by eroding soil [Papendick et al., 1986]. Pesticides enter surface waters through run-off, wastewater discharges, atmospheric deposition and spills [Osman et al., 2010].

Pollution & Harmful Effects Caused by Pesticides

The most important effects of the synthetic pesticides, especially OP pesticides are water and soil pollutions, as well as the contamination of vegetables, fruits, milk, food products and other living organisms. Pollution of the water in the river and depleting its resources can put the lives of many people in danger. OP pesticides are examples of agriculture pollutants that may contaminate feed of livestock, particularly herbage. Cows grazing pastures that are sprayed with OP produce milk with higher pesticide content than cows grazing in unsprayed pastures. Moreover, it has also been reported that the ground water, surface water and drinking water are contaminated with pesticide [Kazemi M. et al., 2012].

Monocrotophos is principally used in agriculture, as a relatively cheap pesticide. Human health effects are caused by 1) Skin contact: handling of pesticide products, 2) Inhalation: breathing of dust or spray and 3) Ingestion: pesticides consumed as a contaminant on/in food or in water. Farm workers have special risks associated with inhalation and skin contact during preparation and application of pesticides to crops. However, for the majority of the population, a principal source is through ingestion of food which is contaminated by pesticides [Calamari D. et al., 1992].

The harmful effects of pesticides are; death of the organism, cancers, tumours and lesions on fish and animals, reproductive inhibition or failure, suppression of immune system, disruption of endocrine (hormonal) system, cellular and DNA damage, teratogenic effects (physical deformities such as hooked beaks on birds), poor fish health marked by low red to white blood cell ratio, excessive slime on fish scales and gills, etc., intergenerational effects (effects are not apparent until subsequent generations of the organism) and other physiological effects such as egg shell thinning[Baker [S, 1990, Margni M et al., 2002]. Monocrotophos is very toxic to aquatic invertebrates; high hazard to aquatic invertebrates from runoff and spray drift; toxic to shrimps and crabs; moderately toxic to fish [Helfrich L et al., 1996]. Monocrotphos is very toxic to birds; one of the most toxic insecticides for birds [Mariel W, 2011].

EXPERIMENTAL
Materials & Instruments

0.05M Sodium Molybdtae Solution, 5M H_2SO_4 Solution, Stock Solution of Phosphorus, 10% $FeSO_4$, Monocrotophos & Dodecyl Trimethyl Ammonium Chloride. (**Note:** All the reagents were of LR & AR grade)

Semi Micro Digital Weighing Balance (RADWAG-LCGC Make, 308552 Model) & visible spectrophotometer (Systronic Make, 1854 Model)

Test Methods to Determine Monocrotophos & Cationic Surfactant

Modified Molybdenum Blue Method was used to determine concentration of Monocrotophos in the water at 825 nm [Rasuljan M et al., 1991]. A rapid and reliable solvent extraction spectrophotometric method was used for the determination of cationic surfactant. Orange II chemically known as p-(_-napthol-azo) benzene sulfonic acid was used as an ion pairing

agent with cationic surfactant [Koner S, 2011].

Adsorption Equilibrium Studies

Batch experiments were carried out in flask of total capacity of 100 ml. The final aqueous volume in each of the flasks was 50 ml. Each solution contained equilibrium dosage of adsorbent. The adsorbent CSMSG, used in the present study, is prepared as shown in *Figure 1*.
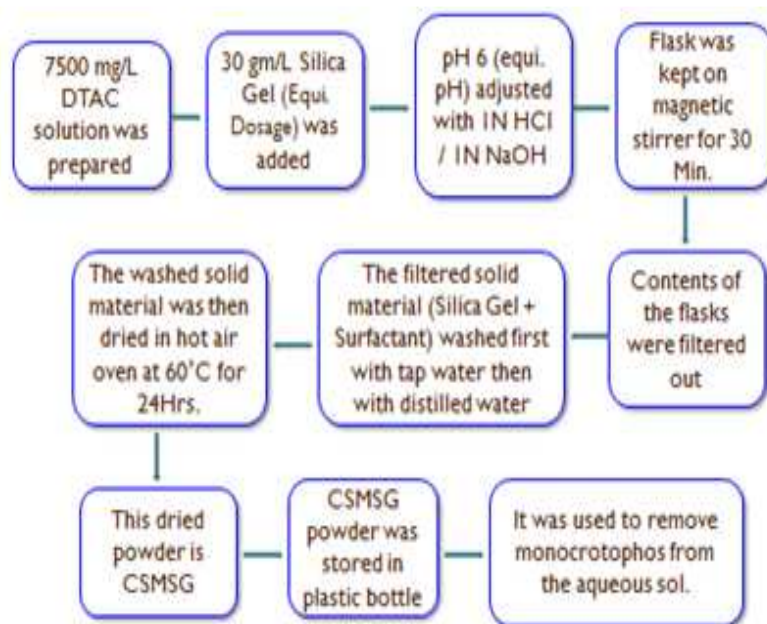
Figure 1: Preparation of Adsorbent Cationic Surfactant Modified Silica Gel

The kinetic study for the removal of monocrotophos by CSMSG was carried out. 50 ml Monocrotophos solution of 15 mg/L high initial concentration was taken in 100 ml beaker. Dosage of the adsorbent was adjusted 8 gm/L. PH 4 (i.e. equilibrium pH resulted from above experiment) was adjusted for all the beakers by adding the required amount of 1N HCl & 1N NaOH. Beakers were kept on the magnetic stirrer for 5, 10, 15, 20, 30, 40 minute. Beakers were allowed to stay for few seconds after shaking time. Supernatant was filtered through ordinary filter paper & filtrate was collected to measure the final concentration of Monocrotophos by using modified molybdenum blue method. Readings were recorded & Graph was plotted to get equilibrium contact time.

Batch Isotherm Studies

Isotherm experiments were conducted to investigate the relationship between the solid phase concentration of an adsorbate & the solution phase concentration of the adsorbate at an equilibrium condition. The removal percentage (R %) of Monocrotophos was calculated for each run by following equation:

R (%) = [(Ci-Ce)/Ci]*100 Where, Ci and Ce are the initial & final concentration of Monocrotophos (mg/L) in the solution [Nameni M., 2008]. The adsorption capacity of the adsorbent for each concentration of Monocrotophos at equilibrium was calculated using following equation: qe (mg/g) = [(Ci-Ce)/M]*V Where, Ci & Ce were the initial & final concentration of Monocrotophos (mg/L) in the test solution respectively. V is the volume of solution (in Liter) & M is the mass of adsorbent (gm) [Nameni M., 2008].

RESULTS & DISCUSSIONS

Effect of pH

The adsorption of anionic species was favored at pH< pHpzc of the adsorbent. The pHpzc of CSMSG was found to be 10.2. At low pH, the CSMSG became more positively charged and should have resulted in greater adsorption of Monocrotphos at lower pH as obtained in several studies [Gupta S et al., 2003, Chao Y, 2008, Hameed B., 2009]. But, in this case, desorption of DTAC from silica surface started at lower pH. This desorption of DTAC reduce surfactant coverage from the surface of Silica Gel and thereby, reduce the uptake capacity at lower pH (<4) [Abdel-Ghani M. et al., 2008]. *Table 1* shows % removal of Monocrotophos from aqueous solution & adsorption capacity of CSMSG at different pH.

Table 1: % Removal of Monocrotophos from Aqueous Solution &
Adsorption Capacity of CSMSG at Different pH

High Initial conc. of Monocrotophos (mg/L)	Adsorbent Dosage Gm/L	Contact Time (Min.)	pH Range	% Removal	Adsorption Capacity q_e (mg/gm)
15	8	20	2	69.1	2.590
			4	**72.6**	**2.721**
			6	56.1	2.105
			8	47.3	1.772
			10	36.0	1.349

Effect of Contact Time

The equilibrium contact time, so found from the experiment, indicates very quick reaction compared to other studies like 90 min using fertilizer waste carbon [Chao Y. et al., 2008]. This decrease in the adsorption rate with increase of time may be due to a distribution of surface sites that cause decrease in adsorbent - adsorbate interaction with increasing surface density [Bansal M., 2008]. Gradually adsorption process got slowed because initially a number of vacant surface sites may be available for adsorption and after some time, the remaining vacant surface site may be exhausted due to repulsive forces between the adsorbent and counter ion binding at the surface of the adsorbate [Chemical Kinetic Study Wikipedia]. Results of % Removal of Monocrotophos by Silica Gel at various contact time is given in table 2.

Table 2: % Removal of Monocrotophos from Aqueous Solution &
Adsorption Capacity of CSMSG at Different Contact Time

High Initial conc. of Monocrotophos (mg/L)	Adsorbent Dosage Gm/L	Equilibrium pH	Contact Time (Min.)	% Removal	Adsorption Capacity q_e (mg/gm)
15	8	4	5	28.7	1.076
			10	44.4	1.666
			15	30.8	1.157
			20	**72.6**	**2.721**
			30	43.0	1.611
			40	51.7	1.939

Effect of Adsorbent Dosages

% Removal of Monocrotophos increases as the CSMSG dosage increases. Maximum % removal was observed at 8 gm/L CSMSG dosage. So we can consider 8 gm/L as equilibrium dosage & can keep that dosage in further studies. The increase in the removal efficiency with the increased dose of adsorbent could be attributed to the increased number of sites available for adsorption [Chemical Kinetic Study Wikipedia]. Results of % removal of Monocrotophos at various adsorbent dosages have been given in *table 3*.

Table 3: %Removal of Monocrotophos from Aqueous Solution &
Adsorption Capacity of CSMSG at Different Adsorbent Dosage

High Initial Conc. of Monocrotophos (mg/L)	Equilibrium Contact Time (Min.)	Equilibrium pH	Adsorbent Dosage (Gm/L)	% Removal	Adsorption Capacity q_e (mg/gm)
			4	5.7	0.213
			8	**72.6**	**2.721**
15	20	4	12	38.7	1.449
			16	54.8	2.055
			20	59.9	2.247

Effect of Initial Adsorbate (Monocrotophos) Concentration

Here, in the present study % removal efficiency was almost same or near the same for all the high initial concentration ranges. Therefore the adsolubilization technique used in present study can be applied to the waste water or aquatic environment containing any concentration range of organ phosphorus group pesticide. Results of % removal of Monocrotophos by CSMSG are given in *table 4*

Table 4: %Removal of Monocrtophos from Aqueous Solution &
Adsorption Capacity of CSMSG at Different Initial
Adsorbate Concentration

| Equilibrium Adsorbent Dosage (Gm/L)	Equilibrium Contact Time (Min.)	Equilibrium pH	High initial conc. of Monocrotophos (mg/L)	% Removal	Adsorption Capacity q_e (mg/gm)
			5	72.8	0.910
8	20	4	15	72.7	2.726
			25	72.6	4.535
			35	72.7	6.364

Effect of Temperature

No change in % removal efficiency was observed at different temperature. From the study maximum 72 % removal of Monocrotophos was observed at all the temperature ranges. Thus it can be concluded that temperature has no effect on the Monocrotophos removal. Results of % removal of Monocrotophos by CSMSG are given in *table 5*.

**Table 5: %Removal of Monocrotophos from Aqueous Solution &
Adsorption Capacity of CSMSG at Different Temperature**

High Initial conc. of Monocrotophos (mg/L)	Equilibrium Contact Time (Min.)	Equilibrium pH	Equilibrium Adsorbent Dosage (Gm/L)	Temp (°C)	% Removal	Adsorption Capacity q_e (mg/gm)
15	20	4	8	30	72.6	2.721
				40	72.0	2.701
				50	72.4	2.716

Chemical Kinetic Study

In the present study pseudo first order, pseudo second order & intraparticle diffusion model were studied. From the chemical kinetic study it was observed that adsorption characteristic follows pseudo second order kinetic model. A pseudo-second order rate expression based on the sorption equilibrium capacity may be represented as: t / qt = 1/ k2qe2 + (1/ qe) t; Where, K2 is the pseudo-second order rate constant (g/mg/min) [Nameni M., 2008]. The value of qe is determined from the slope of the plot of t/ qt versus t as shown in *figure 2 & table 6*.
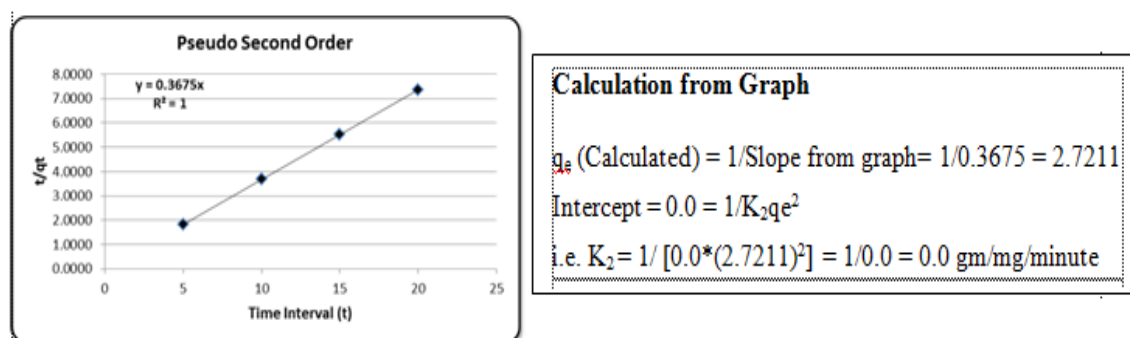
Figure 2: Pseudo-Second Order Kinetic Study for Removal of Monocrotophos by CSMSG

**Table 6: Pseudo-Second Order Kinetic Parameters for
Monocrotophos Adsorption on CSMSG**

Adsorbent	q_e (mg/gm) (Exp.)	q_e (mg/gm) (Cal.)	K_2 (g mg^{-1} min^{-1})	R^2
CSMSG	2.72	2.7211	0.0	1.0

The calculated value of q_e from the pseudo second order model is in very good agreement with experimental q_e value. The obtained value of coefficient correlation (R^2) indicates very good rate of reaction. This suggests that the sorption system follows the pseudo second order model.

Adsorption Isotherm

In the present study four commonly used isotherms viz. Langmuir, BET, Freundlich and Temkin isotherm were studied.

Langmuir Isotherm

It assumes that the uptake of adsorbate occurs on a homogenous surface by monolayer adsorption without any interaction between adsorbed ions. The commonly expressed form is: $C_e/q_e = [1/Q_0 b + 1/Q_0 \times C_e]$

Where, C_e is the equilibrium concentration of adsorbate (mg/L) and qe is the amount of adsorbate adsorbed per gram at equilibrium (mg/g), Q_0 (mg/g) and b (L/mg) are Langmuir constants related to adsorption capacity and rate adsorption, respectively. The values of Q_0 and b were calculated from the slope and intercept of the Langmuir plot of C_e versus C_e/q_e [Bansal M.et al., 2008] as shown in *figure 3 & table 7*.

The Langmuir adsorption isotherm has the simplest form and shows reasonable agreements with a large number of experimental isotherms. Therefore, the Langmuir adsorption model is probably the most useful one among all isotherms describing adsorption, and often serves as a basis for more detailed developments [Noll K. et al., 1992].
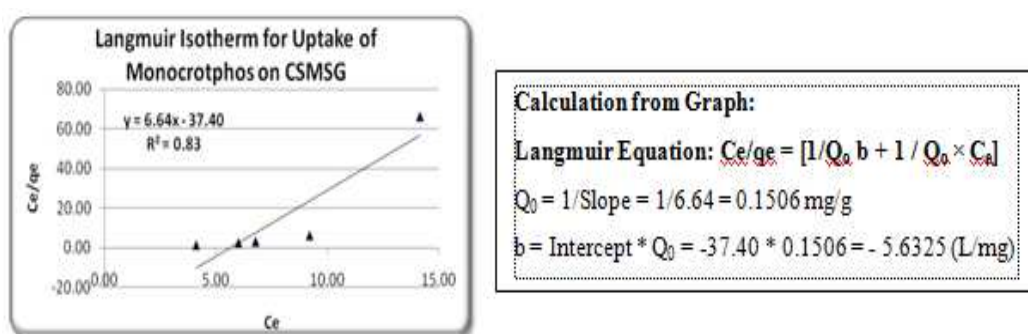

Figure 3: Langmuir Isotherm Plot for Uptake of Monocrotphos on CSMSG from Aqueous Solution

Table 7: Langmuir Constants for Uptake of Monocrotphos on CSMSG from Aqueous Solution

| Q_0 (mg/gm)	b (L/mg)	R^2
0.1506	-5.6325	0.83

The experimental data & value of coefficient correlation R^2 obtained for uptake of monocrotophos on CSMSG have best fit for Langmuir isotherm. It indicates first layer of molecules adhere to the surface with energy comparable to heat of adsorption for monolayer sorption and subsequent layers have equal energies [Sharma M. et al., 2009, Gholizadeh A. et al., 2013]. Here we can say that Langmuir isotherm applies to each layer [Gholizadeh A. et al., 2013, Sawyer C. et al., 2005].

Freundlich Isotherm

The Freundlich isotherm is expressed as: **Log $_{10}$ q$_e$ = log $_{10}$(K$_f$) + (1/n) log$_{10}$ (C$_e$)**

Where, qe is the amount of adsorbate adsorbed at equilibrium (mg/g), and Ce is the equilibrium concentration of adsorbate in solution (mg/L). Kf and n are the constants incorporating all factors affecting the adsorption process [Bansal M. et al., 2008]. Graphical presentation of the Freundlich isotherm is represented in *figure 4*. *Table 8* shows the Freundlich constants calculated from graph.
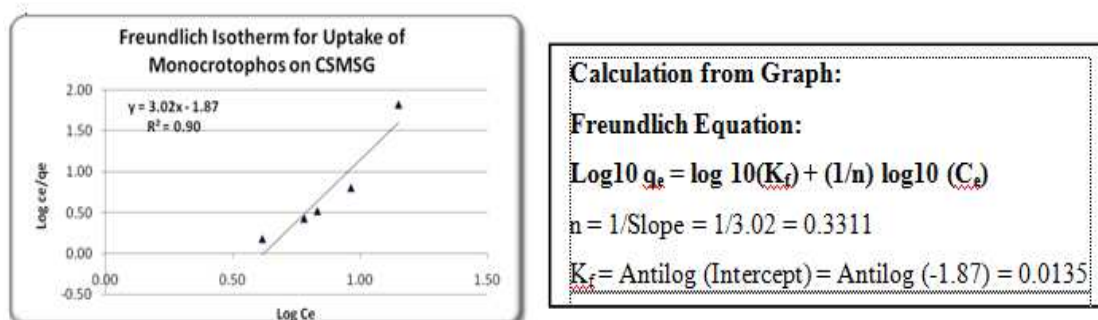
Figure 4: Freundlich Isotherm Plot for Uptake of Monocrotophos on CSMSG from Aqueous Solution
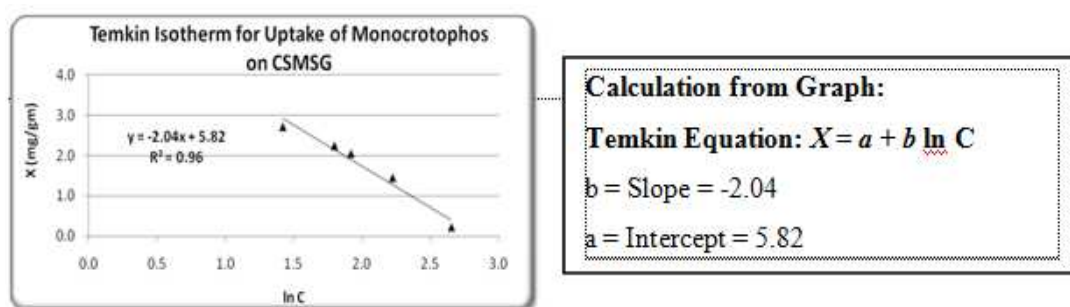
Table 8: Freundlich Constants for Uptake of Monocrotphos on CSMSG from Aqueous Solution

K_f (mg/gm)	n (L/mg)	R^2
0.0135	0.3311	0.90

The value of n fulfills the condition (0 < n < 1) of Freundlich isotherm [Nameni M. et al., 2008, Bansal M. et al., 2008, Ghollizadeh A. et al., 2013]. The value of n in the range 2-10 represent good, 1-2 moderately difficult and less than 1 poor adsorption characteristics [Treybal R., 1981]. The value of coefficient of correlation (R^2) for CSMSG obtained is in good agreement. The value of R^2 is 0.90 indicates good adsorption. Thus CSMSG has best fit for Freundlich isotherm.

Temkin Isotherm

Temkin isotherm model is given by following equation: **X= a + b ln C;** Where, C is the equilibrium concentration of solution (mg/L), X is amount of adsorbate adsorbed per gram weight of adsorbent (mg/g), a and b are constants related to adsorption capacity and intensity of adsorption and related to the intercept and slope of the plots of ln C versus X [Abdel-Ghani N. et al., 2008]. Graphical presentation of the Temkin isotherm is represented in *figure 5*. *Table 9* shows the Temkin constants calculated from graph.

Figure 5: Temkin Isotherm Plot for Uptake of Monocrotophos on CSMSG from Aqueous Solution

Table 9: Temkin Constants for Uptake of Monocrotphos on CSMSG from Aqueous Solution

a (mg/gm)	b (L/mg)	R^2
5.82	- 2.04	0.96

The value of correlation coefficient R2 indicates good agreement with Temkin isotherm. The Temkin isotherm fits the present data because it takes into account for the occupation of the more energetic adsorption sites at first. Here the value of adsorption capacity is highest 2.72 mg/gm for 8 gm adsorbent dosage & then after it is decreasing but in increasing order. It may be the reason for negative value of slope obtained from graph.

BET Isotherm

BET isotherm was developed by Brunauer, Emmett and Teller as an extension of Langmuir isotherm, which assumes that first layer of molecules adhere to the surface with energy comparable to heat of adsorption for monolayer sorption and subsequent layers have equal energies. Equation in its linearized form expressed as:

Cf/ (Cf-Cs) q = 1/Bqmax – (B-1/Bqmax) (Cf/Cs) Where, Cs is the saturation concentration (mg/L) of the solute, Cf is solute equilibrium concentration. B and qmax are two constants and can be evaluated from the slope and intercept [Sharma M. et al., 2009]. Graphical presentation of the BET isotherm is represented in *figure 6*. *Table 10* shows the BET constants calculated from graph.

Calculation from Graph:
BET Equation:
$C_f / (C_s - C_f)q = 1/Bq_{max} - (B - 1/ Bq_{max}) (C_f/C_s)$
$1/B*q_{max}$ = Intercept = 0.005; i.e. B*qmax = 200
i.e. qmax = 200 / 748.2 = 0.2673

$((B - 1)/B*q_{max})$ = Slope = 3.736; i.e. B – 1 = 3.736 * 200 mg/gm
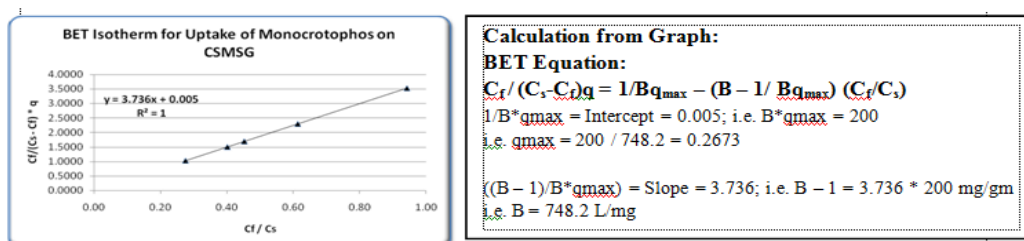i.e. B = 748.2 L/mg

**Figure 6: BET Isotherm Plot for Uptake of Monocrotophos on
CSMSG from Aqueous Solution**

**Table 10: BET Constants for Uptake of Monocrotphos on
CSMSG from Aqueous Solution**

qmax (mg/gm)	B (L/mg)	R^2
0.2673	748.2	1

The experimental value & R^2 value, obtained from graph, for uptake of monocrotophos on CSMSG have best fit for BET isotherms of adsorption. Here we can say that BET isotherm as an extension of the Langmuir isotherm to account for multilayer adsorption and Langmuir isotherm applies to each layer [Sawyer C. et al., 2005]. The much higher value of B i.e. 748.2 L/mg was obtained for uptake of monocrotophos on CSMSG shows higher intensity / rate of adsorption in case of BET isotherm.

Regeneration Study

After removal of Monocrotophos from Waste Water, CSMSG can be regenerated by using mixture of Methanol & Acetone by following method.

- 10 gm of exhausted CSMSG (i.e. CSMSG after Monocrotophos removal) was taken in a beaker.

- 25 ml of Methanol & 25 ml Acetone were added to it.

- The beaker was kept on the magnetic stirrer for 1 Hr at room temperature. The mixture was stirred well.

- Distillation assembly was arranged.

- Then after the mixture of Methanol + Acetone & Monocrotophos was collected in a distillation flask.

- Here, boiling points of Methanol & Acetone are around 56°C & Monocrotophos is 120°C.

- Therefore, distillation process was conducted at 56°C & Methanol + Acetone was distilled out in a collection beaker. The distillate of Methanol + Acetone was collected.

- The remaining Monocrotophos, in a distillation flask, was tested to measure the concentration of Monocrotophos desorbed from the CSMSG & extracted in Methanol + Acetone.

- The final concentration of Monocrtophos was measured by using above mentioned Modified Molybdenum Blue method.

- From the result we found 7.26 mg/L concentration of extracted Monocrotophos. The initial high concentration of Monocrotophos was 15 mg/L & after adsolubilization by 8 gm/L CSMS it was 4 mg/L.

- That means 11 mg/L of Monocrotophos was adsolubilized on CSMSG.

- During Acetone treatment almost 7.26 mg/L of Monocrotophos desorbed from the CSMSG & extracted in the Methanol + Acetone.

- From the results shown in *table 11* almost 66% Monocrotophos was recovered.

- To get maximum recovery of Monocrotophos from exhausted CSMSG, re-extraction was carried out with the mixture of Methanol + Acetone.

- The final concentration of recovered Monocrotophos was measured 3.3 mg/L.

- From the results shown in *table 11* almost 88.2% Monocrotophos can be recovered after re-extraction of Monocrotophos by mixture of Methanol + Acetone.

- Still 0.44 mg/L Monocrotophos remains on CSMSG which is in very less quantity & cannot be treated conventionally.

- % recovery may be extended by using sophisticated instruments & more precise experimental work.

- Then both Monocrotophos as well as CSMSG can be reused for further production or treatment respectively.

Table 11: Recovery of Monocrotophos

Initial Conc. of Monocrotophos (mg/L)	Final Conc. of Monocrotophos (mg/L)	Quantity of Exhausted CSMSG (gm)	Quantity of Methanol + Acetone (ml)	Contact Time for Recovery (Hr.)	Temp. (°C)	Conc. of Monocrotophos Adsolubilized on CSMSG (mg/L)	Conc. of Monocrotophos Extracted by Methanol + Acetone (mg/L)	% Recovery of Monocrotophos
1st Extraction								
15	4	10	25+25	1	25	Ini. Conc. – Final Conc. i.e. 15 – 4 = 11	7.26	66
2nd Extraction (The residues remain after 1st extraction was retreated)								
--	--	10	25+25	1	25	11 – 7.26 = 3.74	3.3	88.2

Removal of Organophosphate Pesticide from the Wastewater Sample of Pesticide Manufacturing Industry

To check the effectiveness of the treatment given to the synthetic sample (as described earlier) the experiment was again performed on actual sample of Pesticide / Insecticide Manufacturing Industry. pH, contact time & adsorbent dosage were adjusted 4, 20 minutes & 8 gm/L respectively (equilibrium from earlier batch studies). Maximum 68.4% removal of Phenol from actual industrial sample by CSMSG was observed where as it was 72.6% for synthetic sample. The results of % removal have been mentioned in *table 12*. From the results it was observed that the CSMSG is an effective adsorbent to remove organic pollutant like organophosphate pesticide / insecticide from industrial wastewater.

Table 12: %Removal of Organophosphate Pesticide / Insecticide
from Actual Sample

Equilibrium Adsorbent Dosage (Gm/L)	Equilibrium Contact Time (Min)	Equilibrium pH	High Initial conc. of Pesticide (mg/L)	Absorbance	Final Conc. of Pesticide (mg/L) (0.098x)	% Removal
8	20	4	6.8	0.213	2.1	68.4

CONCLUSIONS

The present study suggested that CSMSG can be effectively useful in the removal of Organo Phosphate group pesticide/insecticide. Silica Gel changes its characteristic upon adsorption of cationic surfactant DTAC at a pH less than PZC. The cationic surfactant modified Silica Gel is found to have greater adsorption capacity for organo phosphorous group pesticide/insecticide from aqueous media without consuming much energy. Removal of Monocrotophos by CSMSG followed Pseudo Second Order Kinetic Model. Regrational analysis showed that experimental data fitted Langmuir, Freundlich, and Temkin & BET. Maximum 68.4% removal of Organophosphate insecticide was observed for actual pesticide industry effluent sample.

Again the pesticide/insecticide can be regenerated by using Methanol + Acetone – an organic solvent & both can be separated by distillation. Thus separated Methanol + Acetone & Monocrtophos can be re-used as extracting solvents & raw material in the industries.

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